## (12) EUROPEAN PATENT APPLICATION

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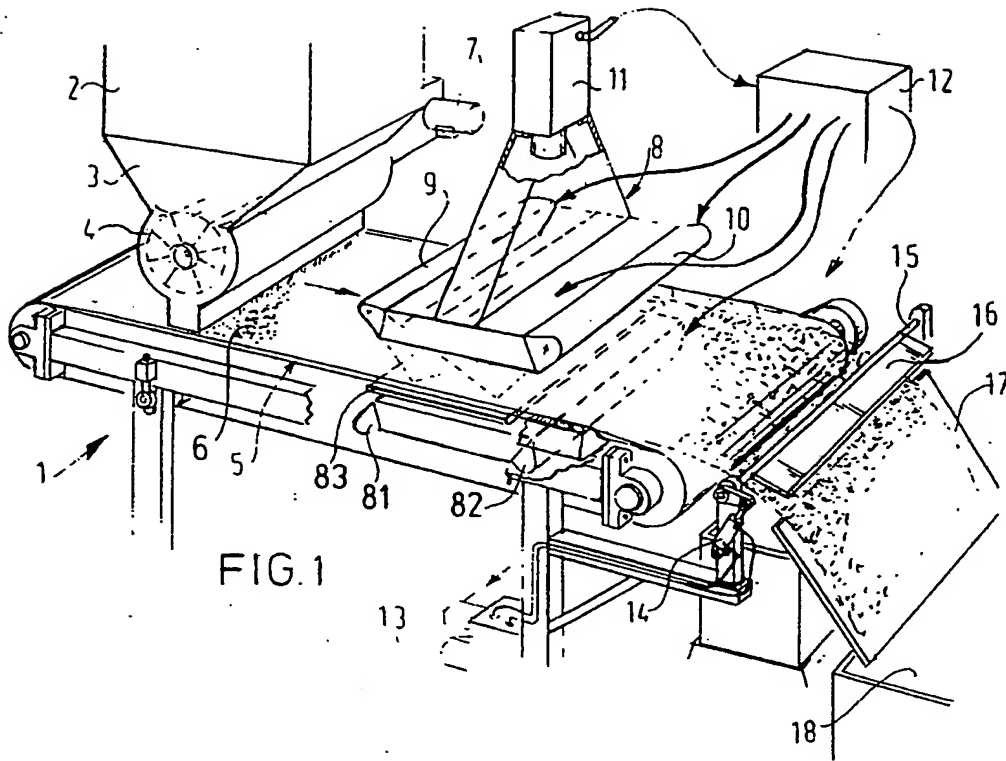(54) Apparatus for inspecting bulk goods.

(57) The invention relates to an apparatus for inspecting bulk goods (6), having an average colour, said apparatus comprising: drivable conveyor means (5); dispensing means (4) for pouring the bulk goods on the conveyor means in such a way, that said goods form thereon a single layer; a light source (9, 10) for illuminating the bulk goods transported by said conveyor means; and a video camera (11) for forming first video signals corresponding to the picture of the bulk goods illuminated by said light source from the side of the video camera and a signal processing unit having a memory, in which previously said colour and the associated tolerance limits are stored; means for forming from the first video signals second video signals representative of the colour of the bulk goods observed by the video camera; comparing means for comparing the contents of the memory with the second video signals and generating a reporting signal in case of a detected difference.

In the prior art with the inspection of coloured objects a problem may occur as a result of the colour transition between the conveyor means and an object observed by the video camera. At a transition from the conveyor means to the object as a result hereof in the camera spurious and disturbing colour variations may occur around the object, that later have to be filtered out electronically in the signal processing unit. It cannot be avoided that such a filtering has negative consequences for the detection accuracy of colour deviations of the product.

In view thereof the invention provides an inspection apparatus of the type mentioned above, characterized in that the background observed by the video camera has substantially the same colour as correct bulk goods.

EP 0 377 478 A1

FIG.1

## Apparatus for Inspecting bulk goods

The invention relates to an apparatus for inspecting bulk goods, such as vegetables, tobacco, granulates and the like, having an average colour within certain tolerance limits, said apparatus comprising:

(1) drivable conveyor means;

(2) dispensing means for pouring the bulk goods on the conveyor means in such a way, that said goods form thereon a single layer;

(3) a light source for illuminating the bulk goods transported by said conveyor means; and

(4) a video camera for forming first video signals corresponding to the picture of the bulk goods illuminated by said light source from the side of the video camera and

(5) a signal processing unit having

(5.1) a memory, in which previously said colour and the associated tolerance limits are stored;

(5.2) means for forming from the first video signals second video signals representative of the colour of the bulk goods observed by the video camera;

(5.3) comparing means for comparing the contents of the memory with the second video signals and generating a reporting signal in case of a detected difference.

Such an apparatus is e.g. known from EP-A-104 369 and US-A-4 235 342.

In the prior art with the inspection of coloured objects a problem may occur as a result of the colour transition between the conveyor means and an object observed by the video camera. In large number of colour CCD-cameras the colour value of each individual pixel is not exactly known. Over the CCD-chip a colour filter is provided transmitting per pixel one of the basic colours red, green or blue, such that for every pixel a colour is determined. The other colours are interpolated from the colours of adjacent pixels. At a transition from the conveyor means to the object as a result hereof in the camera spurious and disturbing colour variations may occur around the object, that later have to be filtered out electronically in the signal processing unit. It cannot be avoided that such a filtering has negative consequences for the detection accuracy of colour deviations of the product.

In view thereof the invention provides an inspection apparatus of the type mentioned above, characterized in that the background observed by the video camera has substantially the same colour as correct bulk goods.

E.g. the apparatus may be characterized in that the background is the upper surface of the conveyor means supporting the bulk goods.

A very simple embodiment is that in which characterized in that the upper surface of said conveyor means has substantially the same colour as correct bulk goods.

E.g. a conveyor belt can be designed in total in the same colour as the bulk goods to be transported, e.g. an orange conveyor belt for inspecting carrots, a red one for tomatoes, a brown one for tobacco, etcetera.

In an alternative embodiment the apparatus is characterized in that the conveyor means are translucent;

a second light source is positioned under the conveyor means;

diffusor means are provided for diffusing light passing said conveyor means; and

colour means are provided;

in such a way that the background is formed by diffuse light having substantially the same colour as correct bulk goods.

The diffusor means may be designed as the conveyor means themselves, that e.g. can be provided with a diffusing lower or upper surface or be opal, whilst also use may be made of a diffusor plate between the conveyor means and the second light source.

The colour means in question may be engineered in different ways. E.g. use may be made of a light source emitting itself light of the desired colour, whilst also use may be made of a colour filter, that is only transparent for the desired colours. This filter may form part of the conveyor means themselves, e.g. be designed as a coloured transparent foil.

By preference the apparatus is characterized in that

the memory is designed as a table (LOOK UP TABLE: LUT) having discrete contents;

the second video signals are transferred into digital format by means of an analog/digital convertor; and

the digitized second video signals are supplied to the table as an address therefore.

The apparatus may be characterized by

means for forming colour signals, e.g. corresponding with the three basic colours red, green and blue, each having a chrominance component and a luminance component; and

a light source emitting light containing the relevant colour(s).

With such a detection on basis of colour observation a very high degree of detection accuracy is realized. The transfer into digital format can take place in this case such that characterized in that the analog/digital convertor transfers the luminance component of each of the colour signals into digital

format of at most eight bits.

The camera can be of the matrix type or the linear type. In case of a matrix camera one can use e.g. mutually partially overlapping pictures, if desired, with intermittent illumination in which case the light source is adapted thereto. Of course, also use may be made of a continuous illumination.

The camera can also be of the linear-array type, in which case the light sensitive elements extend in a direction having a component transverse relative to the conveyor means.

In a further embodiment the apparatus is characterized by selective means for amplifying or attenuating parts of the video signals. This can be engineered e.g. as offset-means for bringing the video signals in a desired band.

In case of a video signal on basis of the three basic colours, the three components from the basis of a six-dimensional space. The reflections of the product and the picture of the conveyor means, particularly a conveyor belt observed by the video camera give picture elements, generally indicated as pixels. These pixels form clusters in the six-dimensional space. These clusters can mutually contain each other in total or in part. Also reflections from the undesired elements to be detected form clusters in this more dimensional space. The signal processing apparatus can distinguish between these clusters.

When using the look up table or LUT the contents of the address determines whether the pixel in question is a picture of a product element, of the background (e.g. the conveyor means) or an undesired element to be detected. The address is supplied to a processing element that on basis of the frequency of occurrence and/or the values of pixels in the vicinity takes a decision relative to the classification of the pixel in question. These data are supplied to a control unit that on basis of the pixel in the picture takes a decision on basis of which the mentioned report signal can or can not energize an ejection station.

The invention will now be explained with reference to the accompanying drawing. In the drawing:

Fig. 1 is a schematic perspective view of a first embodiment;

Fig. 2 is a perspective view partially broken-away and schematically shown of a second embodiment;

Fig. 3 is a schematic perspective view;

Fig. 4 is a partially broken perspective view of a detail of the embodiment according to fig. 3;

Fig. 5 is a strongly simplified block schematic view of an embodiment of the signal processing unit; and

Fig. 6 is a block schematic view of a digitizing unit.

Fig. 1 shows an apparatus 1 for cleansing of bulk good present in a bulk container 2. To this bulk container 2 a funnel 3 is connected for supplying through a dispensing device 4 engineered as a turnstile-lock a thin layer 6 of the bulk goods. The turnstile-lock 4 is driven by a motor 7 in order to achieve the desired dispensing.

The conveyor belt 5 is driven at a speed such that in combination with the speed determined by the adjustment of motor 7 the desired thickness of the layer of bulk goods is obtained.

On some distance down stream relative to the turnstile-lock 4 an inspection device 8 is arranged comprising in this embodiment to tubular flash lamps 9, 10 and a video camera 11. This video camera 11 can supply its output signals to a signal processing unit 12 that can supply control signals to a pneumatic control unit 13 that can energize a pneumatic cylinder 14 on basis thereof. This pneumatic cylinder 14 serves the purpose of causing a swinging movement of a strip 16 around a shaft 15 parallel to the width of the conveyor belt 15, said strip 16 extending over the whole length of transport belt 5. In the situation shown in fig. 1 the strip 16 is in its upper position in which it does not disturb the free path of the bulk goods 6 thrown away by conveyor belt 5 in such a way that this bulk goods can be caught in a bulk container 18 over a screen 17.

In the embodiment according to fig. 1 the apparatus 1 also comprises two tubular flash lamps 81, 82 controlled in synchronism with tube lamps 9 and 10 by the signal processing unit 12 for emitting a light flash. In this embodiment according to fig. 1 the conveyor belt 5 is transparent and between the conveyor belt 5 and flash lamps 81, 82 a diffusor plate 83 is arranged for diffusing the light emitted by lamps 81, 82 and besides being coloured in correspondence with the colour of the transported bulk goods 6. Thus the video camera sees a background having the same colour as the colour of correct bulk goods. For as good as possible a detection reliability and detection accuracy preferably the intensities of the respective light sources 9, 10 and 81, 82, 83, 5 are mutually adapted, as a result of which the respective gray values of the background and the products or the bulk goods to be inspected differ only little.

In a situation not shown in fig. 1 as a result of energizing the pneumatic cylinder 14 the strip 16 is positioned in its down position as a result of which the free path of the bulk goods thrown away by conveyor belt 5 is temporarily interrupted, so that a certain amount of that bulk goods is deflected and caught in a second storage container 19 in which all rejected bulk goods are gathered for dumping.

Fig. 2 shows a different embodiment 20, in which no use is made of only one strip 16, but rather eight aligned plates 21 - 28. All plates are up

and down swingable under control by pneumatic cylinders of which those added to plates 23 - 28 are indicated with reference numerals 29 -34. In the situation shown in fig. 2 the pneumatic cylinders 29 and 30 are activated, as a result of which the plates 23 and 24 are brought into the free path of the bulk goods 6 due to which the corresponding part thereof is deflected in downward direction. The free path is indicated with 35 and the deflected path is indicated with 36.

Also in this embodiment a screen indicated with 37 is present in order to avoid undesired straying of the loose bulk goods. –

The displacement of the plates 21 - 28 is controlled by video cameras 38 - 45 that observe in the manner indicated schematically with interrupted lines 46 a zone of the layer 6 bulk material for generating their output signals and supplying them to a not-shown signal processing unit that in accordance with the construction of the apparatus according to fig. 1 uses the output signals of the video camera 38 for the control of plate 21, those of camera 39 for plate 22, etcetera.

Fig. 3 shows an apparatus 47 corresponding in several aspects with the apparatus according to fig. 1. Corresponding parts are indicated therefore in fig. 3 with the same reference numerals as they are in fig. 1.

Different from the apparatus according to fig. 1 the apparatus 47 according to fig. 3 comprises only the light source 9, 10. The conveyor belt 84 is, different from the conveyor belt 5 according to fig. 1 not transparent, but opaque and has an upper surface having the same colour as the bulk goods 6 to be inspected. In accordance with fig. 1 by this measure it is achieved that the gray values of the products or the bulk goods to be inspected and background observed by the video camera differ only little.

The video camera supplies its output signals to a signal processing unit 48 that different from the embodiment according to fig. 1 controls not only one element, but rather a plurality of aligned and each individually energizable electromagnetic valves 49, arranged on nozzles 50 in the manner shown in fig. 4 in a pressure conduit 52 connected with a source 51 for pressurized air, in such a way that by opening a valve by corresponding energizing from the signal processing unit 48 an airflow indicated with reference numeral 53 is directed to the layer 6 of bulk material in its free path in such way that this free path is interrupted and is changed into a path having a greater downward speed, as indicated with reference numeral 54.

It will be obvious that the signal processing unit 48 according to fig. 3 differs from the signal processing unit 12 according to fig. 1 in that it has to be adapted for deriving from only one video signal

a plurality of signals for the selective control of valves 49.

Fig. 5 shows schematically the construction of an embodiment of a part of the inspection apparatus according to the invention.

The video signals supplied by a video camera, in this example video camera 11 comprise the colour components red (R), green (G), blue (B). These colour components supplied by camera 11 or a preprocessor making RGB from composite video are each supplied to a respective digitizer 61, 62, 63. These digitizers are mutually identical. In fig. 6 the block schematic construction of unit 61 is shown and explained with reference thereto.

Each digitizer 61, 62, 63 supplies in this embodiment six-bits information that is related to the strength of the related input signal. The three times six bits are simultaneously supplied to a look up table or LUT 64 having a width of eighteen bits. These eighteen bits determine unambiguously an address location in the LUT 64. The contents of the LUT 64 is determined in a learning phase to be herein described in more detail and comprises one- to eight-bits information or the colour combination which is determinative whether or not a certain signal composition indicates a product, the transport conveyor, or defects. This one to eight bits information is then supplied to an post-processor 65 that determines the relation of each pixel relative to its neighbours. This unit may e.g. be the unit APA-512-MX that is supplied by the Australian firm Vision Systems. This unit is capable of generating a large number of data regarding the magnitudes and shapes of surfaces of neighbouring pixels having corresponding bit values. The unit 65 can also be a so-called SNAP (Systolic Neighbourhood Array Processor) in combination with a so-called feature-max, such as e.g. sold by the firm Datacube, United States of America. The SNAP is capable of classifying a pixel in combination with its eight most close neighbours. This classification can be stored in the feature-max. A central control unit 66 eventually controls the reading-out of the post-processor 65 and, on basis of previously determined criteria takes a decision relative to the energizing, if necessary, of an ejector (see figures 1, 2 3 and 4). This central control unit also controls the initializing of each part and the control of the whole signal processing.

Monitoring of the process can take place by means of a monitor 73 receiving signals from the output of LUT 64 through a DA-converter 74.

Fig. 6 shows as an example the block schematic form of digitizer 61. The video information at the input 67 hereof is supplied to a sync-stripper 68 that removes the video control signals from the input video signal. Then the signal is amplified by a controllable amplifier 69 and provided with a con-

trollable offset in an offset unit 70. The signal supplied thereby is digitized by a six-bits analog/digital-converter 71. The output signal thereof is supplied to a LUT 72 for further processing, e.g. inversion. As indicated in fig. 6 control takes place from the central control unit 66.

During the "learning phase" for a large number of different objects of the products the eighteen-bits colour information of product and background is determined. This information results in a histogram in the three-dimensional colour space. From this histogram it is deduced which combination of the eighteen bits can be classified unambiguously as product, which as background, which as reflections, and which as transition phenomena. These last can be picture edges or shadows. This classification offers the opportunity to substantially fill-in the LUT 64. This filling-in determines whether or not a certain combination is desired. The exact filling-in is dependent upon the nature and the construction of the post-processor 65 and can have a width of one to eight bits. In practice for a certain case possibly only three values may be relevant, namely good, faulty and not to be decided. The manner in which from the above-mentioned histogram the allowability criterium can be derived is per se known from mathematics. The algorithms to be used in order to make this derivation can vary in principle from product to product. An important criterium herein is the calculation time. Dependent upon the product colour(s) and the defect colour(s) simple or more advanced algorithms may be used.

Finally it should be noted that it has not been shown that the central control unit 66 controls the energizing of an ejector on basis of the information signals supplied thereto.

## Claims

1. Apparatus for inspecting bulk goods, such as vegetables, tobacco, granulates and the like, having an average colour within certain tolerance limits, said apparatus comprising:
(1) drivable conveyor means;
(2) dispensing means for pouring the bulk goods on the conveyor means in such a way, that said goods form thereon a single layer;
(3) a light source for illuminating the bulk goods transported by said conveyor means; and
(4) a video camera for forming first video signals corresponding to the picture of the bulk goods illuminated by said light source from the side of the video camera and
(5) a signal processing unit having
(5.1) a memory, in which previously said colour and the associated tolerance limits are stored;
(5.2) means for forming from the first video signals second video signals representative of the colour of the bulk goods observed by the video camera;
(5.3) comparing means for comparing the contents of the memory with the second video signals and generating a reporting signal in case of a detected difference;
characterized in that
the background observed by the video camera has substantially the same colour as correct bulk goods.

2. The apparatus according to claim 1, characterized in that the background is the upper surface of the conveyor means supporting the bulk goods.

3. The apparatus according to claim 2, characterized in that the upper surface of said conveyor means has substantially the same colour as correct bulk goods.

4. The apparatus according to claim 2, characterized in that the conveyor means are translucent;
a second light source is positioned under the conveyor means;
diffusor means are provided for diffusing light passing said conveyor means; and
colour means are provided;
in such a way that the background is formed by diffuse light having substantially the same colour as correct bulk goods.

5. The apparatus of anyone of the preceding claims, characterized in that
the memory is designed as a table (LOOK UP TABLE: LUT) having discrete contents;

the second video signals are transferred into digital format by means of an analog/digital convertor; and
the digitized second video signals are supplied to the table as an address therefore.

6. The apparatus according to anyone of the preceding claims, characterized by
means for forming colour signals, e.g. corresponding with the three basic colours red, green and blue, each having a chrominance component and a luminance component: and
a light source emitting light containing the relevant colour(s).

7. The apparatus according to claims 5 and 6, characterized in that the analog/digital convertor transfers the luminance component of each of the colour signals into digital format of at most eight bits.

8. The apparatus according to anyone of the preceding claims, characterized in that the camera is of the matrix type.

9. The apparatus according to anyone of the preceding claims, characterized in that the camera is of the linear type.

10. The apparatus according to anyone of the preceding claims, characterized in that the light source is of the continuous type.

11. The apparatus according to anyone of the preceding claims, characterized in that the light source is of the intermitting type and emits e.g. light flashes.

12. The apparatus according to claim 6, characterized by selective means for amplifying or attenuating parts of the video signals.

13. The apparatus according to claim 12, characterized by offset-means for bringing the video signals within a desired band.

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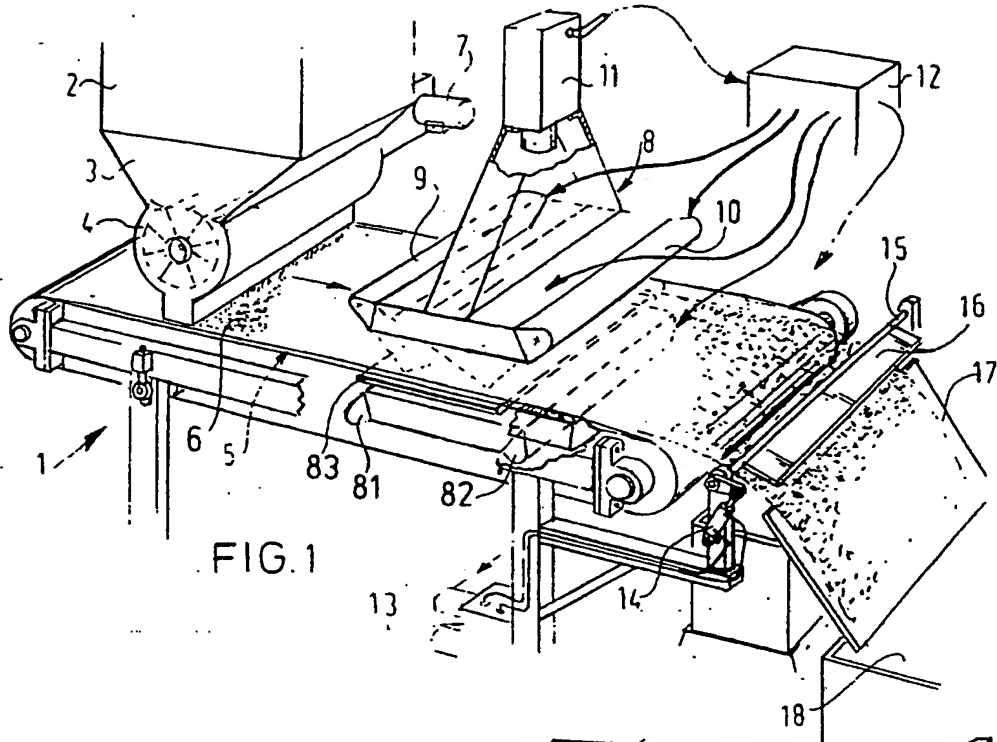45

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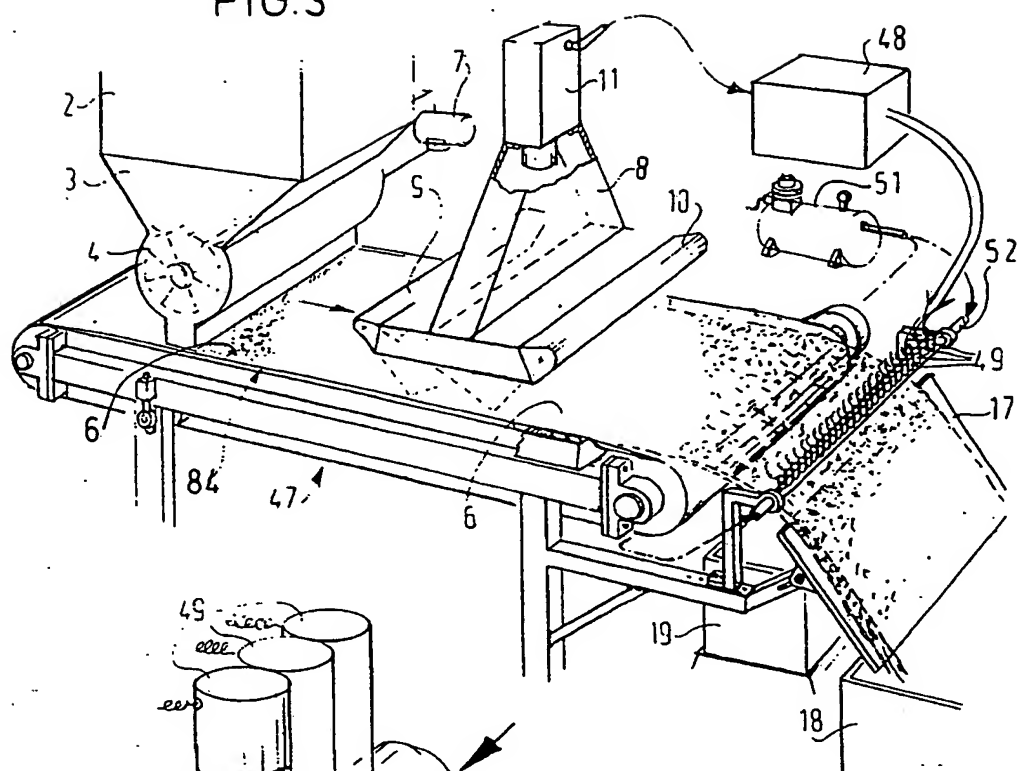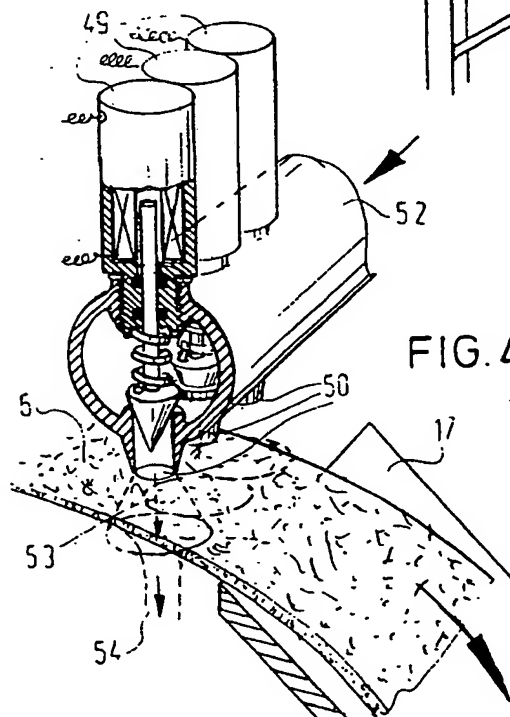55
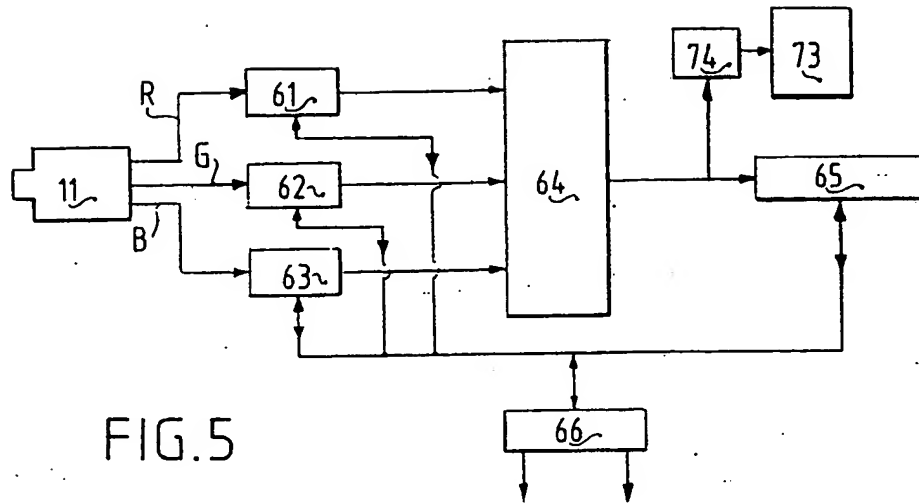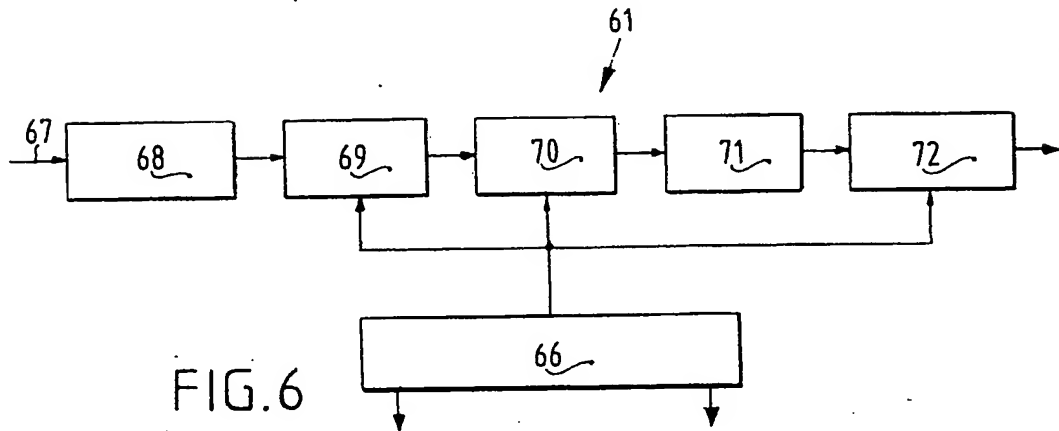
FIG.1

FIG. 2
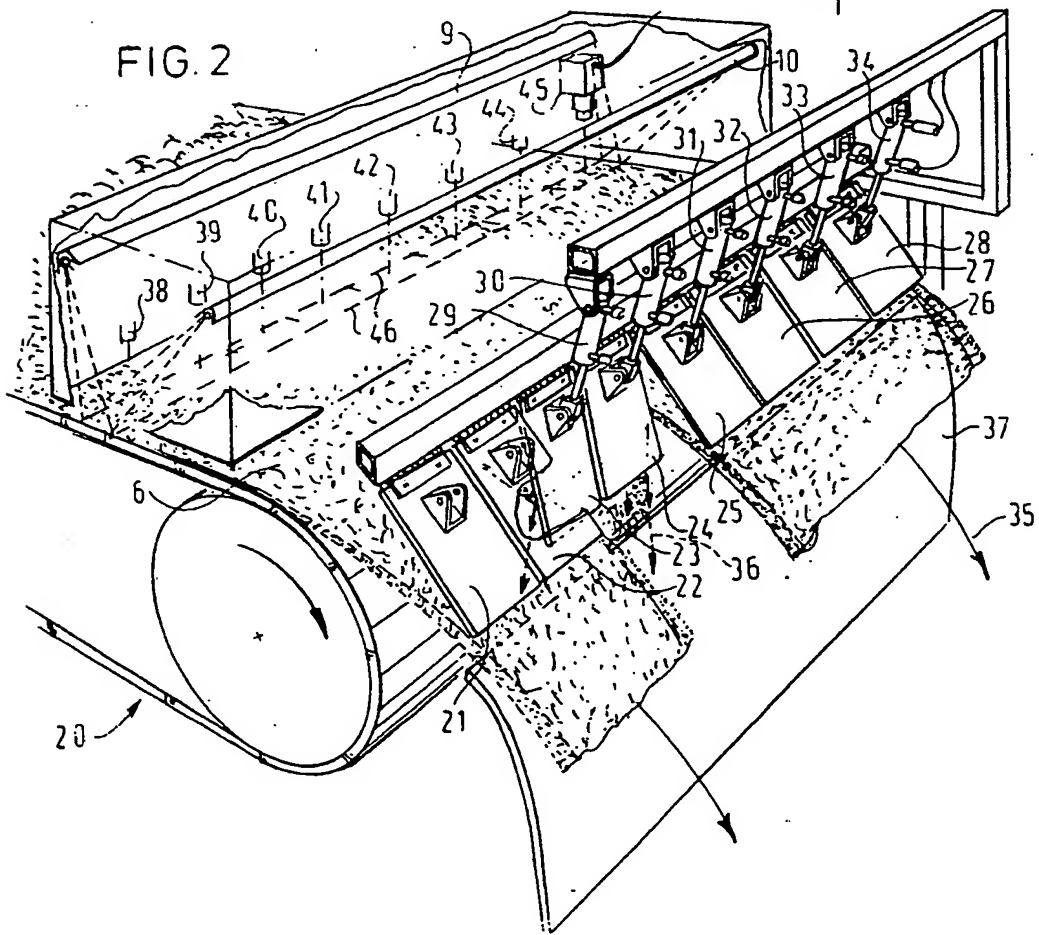
FIG.3

FIG.4

FIG.5

FIG.6

## DOCUMENTS CONSIDERED TO BE RELEVANT

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim | CLASSIFICATION OF THE APPLICATION (Int. Cl.5 ) |
|---|---|---|---|
| Y | EP-A-194148 (LOCKWOOD GRADERS) <br> * page 1, line 4 - page 6, line 24 * <br> * page 20, line 17 - page 23, line 22; figures 2-4 * | 1-8, 10 | B07C5/342 |
| Y | FR-A-2430272 (BLITZ ELECTRICITE) <br> * page 4, lines 22 - 28; figure 1 * | 1-8, 10 | |
| Y | US-A-2645343 (C.T.NEMIR) <br> * column 3, line 3 - column 4, line 16; figures 1-2 * | 1-8, 10 | |
| D,A | US-A-4235342 (BRAHAM) <br> * claims 1-6 * | 1, 5-7, 10, 12-13 | |
| D,A | EP-A-104369 (L. PIETZSCH) <br> * abstract; figures 9-10 * | 1, 5-6, 9 | |
| A | GB-A-1283902 (GUNSON'S SORTEX) <br> * page 2, lines 70 - 87; figures 1-4 * | 1 | TECHNICAL FIELDS SEARCHED (Int. Cl.5 ) <br><br> B07C |

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| THE HAGUE | 17 APRIL 1990 | GYSEN L.A.D. |

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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